SIT782

Systems Integration Overview & Data science SRS

Version 2.0 [Draft]

John Collins
223617689

Contents

Version History

`	Changes by	Update Notes	Comment
1.0	John Collins	Initial Draft	Links need to be added.
1.1	John Collins	Updated Uses Cases, Data Model, Database Design	T3 2024

Documentation Github Links

1. **Updated EVAT Application Integration & DataScience SRS Overview.pdf**
   https://github.com/Chameleon-company/EVAT-Data-Science/blob/49bbf248a191ff91964af057b0a842fcbc5f1fcc/personal-work/john-collins/Chameleon%20EVAT%20Application%20Integration%20%26%20DataScience%20SRS%20Overview.pdf

2. **Test Data Model Development**
   EVAT-Data-Science/personal-work/john-collins/Testing-Data-Model-Development at john-collins-documentation · Chameleon-company/EVAT-Data-Science

3. **Project Work**
   EVAT-Data-Science/personal-work/john-collins at john-collins-documentation · Chameleon-company/EVAT-Data-Science

User Centered Solution Design Approach

User-centered design is an iterative design process that focuses on understanding the users and their needs, as the solutions is progressed to delivery using an agile methodology. It involves creating the following artifacts which fit together to describe the :

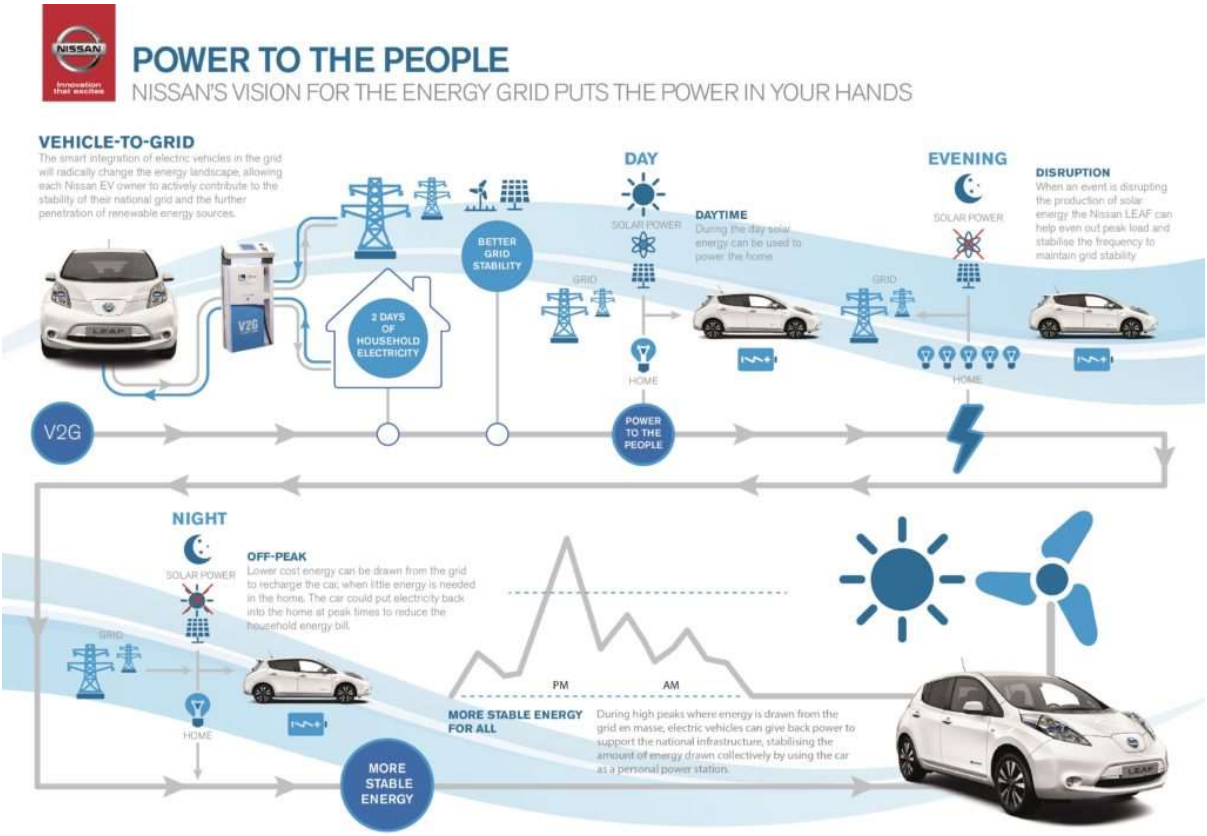
- **High-Level Problem Statement:** This is a brief and precise description of the problem you are solving and what you are trying to achieve.
- **Product Solution Vision:** This is the goal or vision of what the product aims to achieve.
- **User Stories:** These are short statements(Stories) about a feature, written from a user's perspective. All the user stories collectively represent the product vision, that a user would like to achieve, and collectively, they help gather and verify user requirements.
- **Use Case Model:** This model shows how users interact with the system.
- **Data Class Model:** These are the data structures or entities in the system that are relevant to the user's interactions with the system.
- **Data Flow Diagram:** This is a representation of the flow of data through the system, showing how information is processed.

These artifacts together help ensure that the designed solution remains focused on the user, leading to a product that is tailored to meet the use needs and provide a positive user experience.

Project Background

The target users for the EVAT would primarily be electric vehicle (EV) owners and drivers. This includes both individuals who own personal EVs and businesses that operate fleets of EVs. We can be informed by previous Electric Vehicle and Charging Research as we develop and expand the solution [1],[2],[3],[4],[5].

In addition, the EV ecosystem has been previously described and is reproduced from [6] *The Future of Electric Vehicles: Mobile Energy Storage Devices | EVAdoption. (2018, February 18).*



Hi Level Requirements

Design and develop a mobile app solution for finding EV charging stations would have the following features [See Appendix - A]:

1. **User Location:** The app would use the user's location to identify nearby EV charging stations. Users could also enter a destination address to search for charging stations along their route.
2. **Charging Station Map:** The app would display a map showing the locations of nearby charging stations. Users could zoom in on the map to see more details about each station.
3. **Station Information:** The app would provide information about each charging station, including the type of charger, availability, cost, and hours of operation. Users could filter their search results based on these criteria.
4. **Reservation System:** The app would allow users to reserve a charging station in advance, ensuring that they have access to a charger when they need it.
5. **Payment Integration:** The app would integrate with payment systems, allowing users to pay for their charging session directly through the app.
6. **User Reviews and Ratings:** The app would include a user feedback system, where users can rate charging stations and provide feedback on their experience. This would help other users make informed decisions
when choosing a charging station.

7. **Rewards System:** The app could include a rewards system, where users earn points or discounts for using certain charging stations or for using the app frequently.

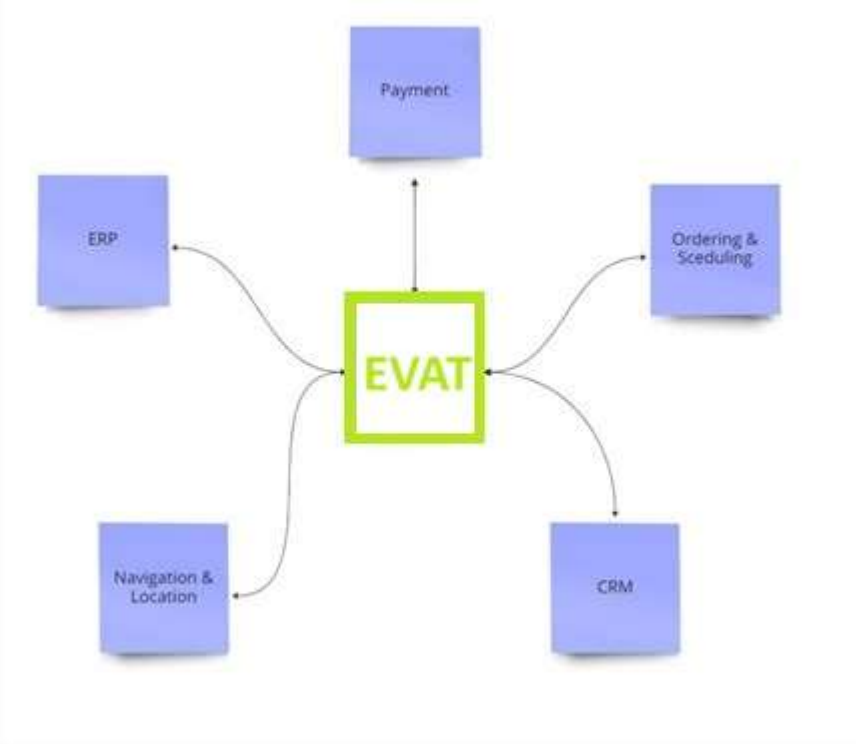
Product/Solution Vision

The following elaborates on how our product/service distinguishes itself from existing offerings available to users:

Product/Solution Vision	Explanation
For	EV Owners & Drivers
Who	Own or drive electric vehicles that have a limited travel range and need recharging and are faced with limited EV stations/Charge Points and it also restricts EV Owners & Drivers that want to undertake long than EV range journeys.
The product/Service	EVAT Mobile App & Web UI
That	Is a UI/software solution which helps the EV owners & drivers search, find and navigate to EV stations/charge points within Vehicle range, and display this information on a map and provide routing (navigation assistance) to the a desirable EV Charge point.
Unlike	Google maps
Our Product	Provides users, Station Information, with real-time reservation Payment Integration, User Reviews and Ratings, Rewards and additional value-added services (e.g Eco-environmental Information, Station amenities etc.)

System Context

A System Context is a high-level, abstract representation of a software system's interactions with its external entities and boundaries. For this application the external entities are the Enterprise Resource Planning System, Navigation & Location Information Systems, Customer Relationship Management Systems, Reservation (Ordering & Scheduling) Systems and the Payments Integration Systems.



The objective was to create alignment with agreed-upon **architectures**, which included **defining system components, interfaces, and workflows to ensure the system functions** effectively and efficiently.

Solution Implementation: High Level Problem Statement

The target users for the "EVAT" Mobile App and Web Ui would primarily be electric vehicle (EV) owners and drivers. To develop the intended application the following high-level problem statement was developed:

High Level Problem Statement	Explanation
Problem	EV have a limited travel range and need to recharge. There are a growing but limited EV stations/Charge Points.
Affects	EV Owners & Drivers
Which impacts	How far the EV owners can drive before recharging. It also EV Owners & Drivers that want to undertake long than EV range journeys.

A successful solution would be	A software solution which helps the EV owners & drivers, search, find and navigate to desired EV stations/charge points within Vehicle range, displaying location and routing information on a map.

Research & Reference Solutions

To develop the "EVAT" Mobile App and Web UI, we need to extract user stories, use cases, and a data model before implementing the database. The target users are primarily electric vehicle (EV) owners and drivers. The high-level problem statement identifies the limited travel range of EVs and the growing but limited number of EV stations/charge points. This affects how far EV owners can drive before needing to recharge and impacts those who want to undertake longer journeys.

A successful solution would be a software application that helps EV owners and drivers search for, find, and navigate to desired EV stations/charge points within vehicle range, displaying location and routing information on a map. This work is based on previous academic research by Singh, Pal, and Garg (2021) [7] on sustainable development through engineering innovations, which is elaborates on detailing ‘Sketching of EV Network: A Complete Roadmap’, in the context of a UI and database design.

Message Copilot

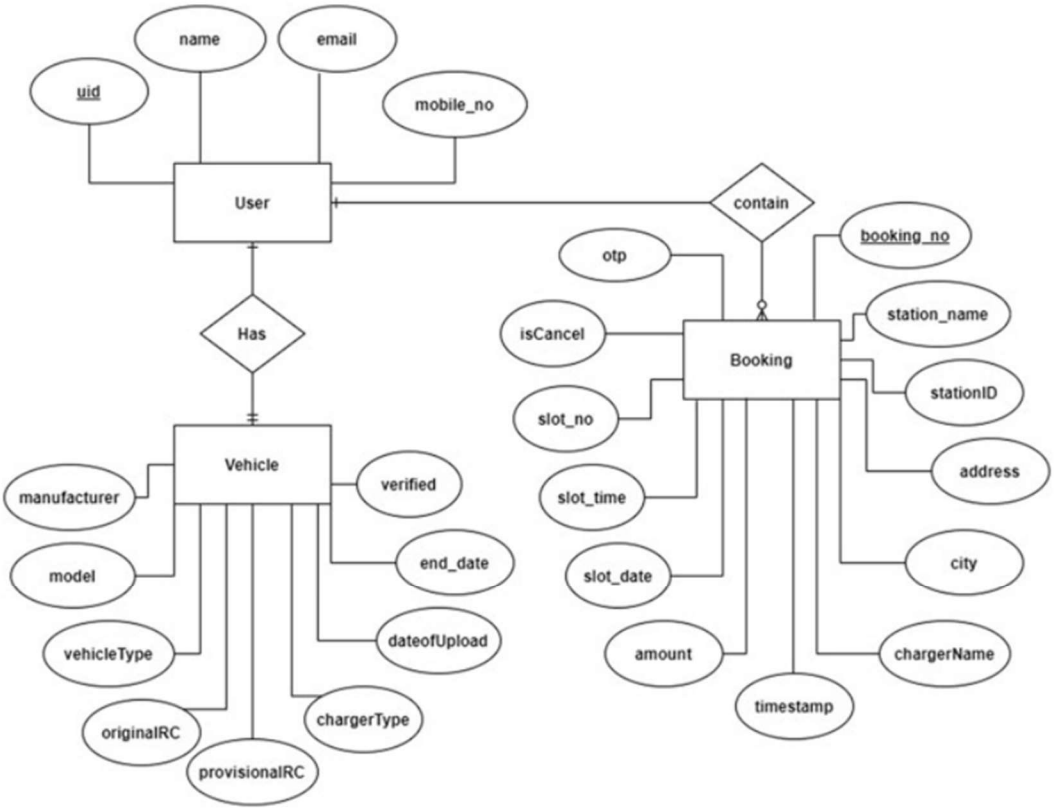


Fig. 3 ER diagram for user, vehicle and booking attributes

Sketching of EV Network: A Complete Roadmap 439

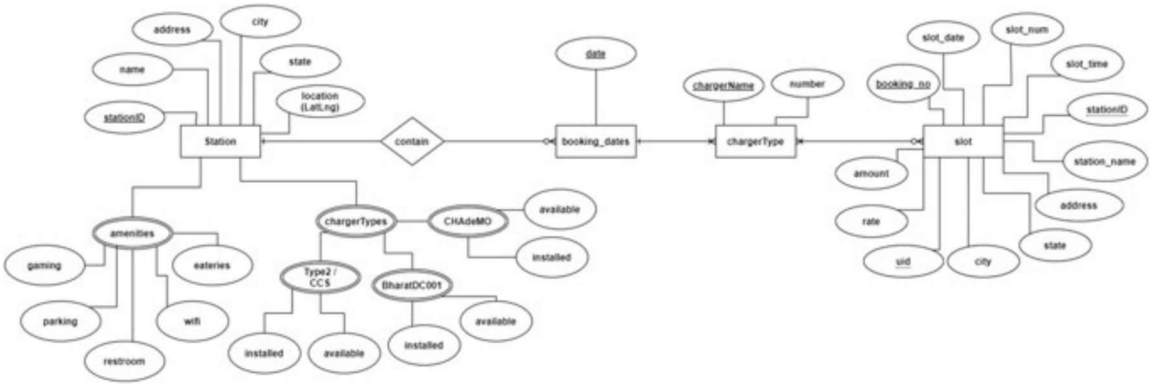


Fig. 4 ER diagram for EV station attributes necessary for database design

Additional research on EV charging systems can be located [8],[9],[10].

EV User Stories

User stories provide a 'user-centric' perspective that helps us understand the user's needs and expectations. They serve as a guide and valuable tool to the design teams in defining the software's functionality and guiding its development process.

EV1 User Location (Search & Find EV ChargePoint's Locations)

Detailed User Story Github link : TBA

User Story	Story Name#EV1: Search & Find EV Chargepoints Locations
As a	EV Owners or Driver.
I Want to	Search, and find a number of EV Charge Stations compatible with my EV (and see real-time availability), in my vicinity (of current or along the route to a planned destination location)
So That	I can select one EV that I can conveniently charge my EV immediately in vacant EV charge points, before my vehicle runs out of charge and without having to wait a long time.

EV2 Charging Station Map with Navigation to EV Charge Point

Detailed User Story Github link : TBA

User Story	Story Name#EV2: Charging Station Map with Navigation to EV Charge Point
As a	EV Owners or Driver.
I Want to	See EV Stations on a Map and Navigate with directions to the desired EV ChargePoint
So That	With the Charging station Map it makes it easy to find and to drive to new EV ChargePoint addresses without getting lost, before my vehicle runs out of charge and without having to wait a long time. Also allows the user to see more details about each station.

EV3: EV ChargePoint booking & Secured with Pre-payment

User Story	Story Name#EV3: EV ChargePoint booking & Secured with Pre-payment
As a	EV Owners or Driver.
I Want to	Secure an available EV Charging Timeslot with pre-payment.
So That	I can charge my EV without having to wait a long time.

EV4: Seamless Service Delivery / Vehicle Charging

User Story	Story Name#EV4: Seamless Service Delivery / Vehicle Charging
As a	EV Owners or Driver.

I Want to	Seamless experience upon arrival at the EV ChargePoint
So That	Without duplicating data entry so I can charge my vehicle without delay.

EV5: Specific EV ChargePoint Value Add-Services & Amenities.

User Story	Story Name#EV5: Specific EV Chargepoint Value Add-Services & Amenities.
As a	EV Owners or Driver.
I Want to	Be informed of close-by additional value-add services and amenities
So That	I can utilize my time efficiently.

EV6: Loyalty Program Location Based Rewards

User Story	Story Name#EV6: Loyalty Program Location Based Rewards
As a	EV Owners or Driver.
I Want to	Received Loyalty rewards & be advised of partner promotions
So That	I can received express and upgrade rewards or discounts.

EV Service Provider User Stories

SP_1: Demand Forecasting

User Story	Story Name#SP_1: Demand Forecasting
As a	Service Provider of EV Chargepoints
I Want to	Understand the demand capacity & wait-times of where EV drivers/owners are search for services and Locations where the demand for EV Chargepoint services is unmet.
So That	Plan the expansion of existing EV ChargePoint capacity or find new business opportunities of where to build new viable EV Chargepoints facilities.

SP_2: Supply Procurement

User Story	Story Name#SP_2: Supply Procurement
As a	Service Provider of EV Chargepoints
I Want to	Forecast EV Demand and Supply
So That	Buy wholesale Electricity at off peak rates and plan appropriate ChargePoint EV ChargePoint Storage to offer EV Drivers & Owners the best market prices.

SP_3: Specific EV Chargepoint Value Add-Services & Amenities.

User Story	Story Name#SP_3: Specific EV Chargepoint Value Add-Services & Amenities.
As a	Service Provider of EV Chargepoints
I Want to	Inform
So That	Differentiate from other EV ChargePoint Service Providers

SP_4: Loyalty Program Location Based Rewards

User Story	Story Name#SP_4: Loyalty Program Location Based Rewards
As a	Service Provider of EV Chargepoints
I Want to	Have an EV Loyalty Program
So That	EV Drivers & Owners Loyalty Rewards can receive express and upgrade rewards or discounts.

SP_4a: User Sign Up or Login In or Vehicle registration or Updates

User Story	Story Name#SP_4: User Sign Up or Login In or Vehicle registration or Updates
As a	Service Provider of EV Chargepoints
I Want to	Require User Sign Up or Login In or Vehicle registration or Updates
So That	The best traceable end-to-end service experience can be offered to EV Drivers & Owners, and additional rewards and discounts can be offered from the Loyalty Program.

SP_5: Broadcast Compatibility info & Update Vacancy/Capacity EV Chargepoints Data in Real-time.

User Story	Story Name#SP_5: Broadcast Compatibility info & Update Vacancy/Capacity EV Chargepoints Data in Real-time.
As a	Service Provider of EV Chargepoints
I Want to	Inform the EV Drivers and Owners of current EV ChargePoints Vacancies in real-time.
So That	Maximize the usage/volume/throughput of EV Chargepoints.

SP_5: Broadcast & Update EV Chargepoints estimated wait times.

User Story	Story Name#SP_5: Broadcast & Update EV Chargepoints estimated wait times.
As a	Service Provider of EV Chargepoints
I Want to	Inform the EV Drivers and Owners of current or anticipated EV ChargePoints Wait-Times in real-time.
So That	Wait times minimization is tied to key business operational performance and business improvement/opportunity metrics,

	such EV Driver/Owner Frustration is avoided by proactively managing demand and EV Charge point capacity efficiently.

SP_6: Seamless Service Delivery / Vehicle Charging

User Story	Story Name#SP_6: Seamless Service Delivery / Vehicle Charging
As a	Service Provider of EV Chargepoints
I Want to	Recognize and efficiently guide EV vehicles to a vacant charge point or queue.
So That	A seamless and efficient EV Charging experience is presented to the EV Driver/Owner using automation upon arrival at the chargepoint.

SP_7: Broadcast Compatibility info & Update Vacancy/Capacity EV Chargepoints Data in Real-time (Unscheduled)

User Story	Story Name#SP_7: Broadcast Compatibility info & Update Vacancy/Capacity EV Chargepoints Data in Real-time.
As a	Service Provider of EV Chargepoints
I Want to	Update changes in Service Provider Locations & Capacity@Locations that result from maintenance, supply interruption, unplanned business closure or new additional capacity.
So That	So EV Drivers/Owners are updated on informed in real-time to avoid inconvenience and delays.

SP_8: EV ChargePoint booking & Secured with Pre-payment

User Story	Story Name#SP_8: EV ChargePoint booking & Secured with Pre-payment
As a	Service Provider of EV Chargepoints
I Want to	Allow EV Users to secure an EV ChargePoint place/timeslot with payment and update/change EV chargepoint booking details
So That	That customer wait times are minimized, by ensuring space/timeslot is reserved. Enable the Service Provider to maintain and up-to-date view of current and forecasted demand.

SP_9: Secure Payment Transaction/Process

User Story	Story Name#SP_9: Secure Payment Transaction/Process
As a	EV Owners or Driver.
I Want to	Offer customer a secure payment process
So That	Customer are confident and assured that the payment process will protect their personal and financial details.

SP_10: Order & Scheduling Updates

User Story	Story Name#SP_10: Order & Scheduling Updates
As a	EV Owners or Driver.
I Want to	Be able to allow EV Owners or Driver. update EV ChargePoint order & scheduling details
So That	EV Owners or Driver, can easily change their mind on the selected EV ChargePoint if their journey needs or preference change.

Use Cases

User stories are often used to describe the high-level functionality of the system and can be broken down into multiple use cases. Each use case provides a detailed description of how the system will be used to accomplish the goal described in the user story.
The following are the use cases for the Electric vehicle EVAT Mobile & Web App.

UC_1 Search & Find EV ChargePoint's Locations

User Case	Use Case# & Name & : UC_1 Search & Find EV Chargepoints Locations
Primary Actor	EV Owners/Drivers.
Secondary Actor	Service Provider
Description	Search & Find EV Chargepoints Locations
Basic Flow (Steps)	• Select current location[Pre-populated GPS] from Drop-down Menu • [Optional] Logged in User, Retrieve User/EV Preferences. Update. • Update Locations of (limited Number) EV Stations on a Map
Alternative Flow1	• Select current location[Pre-populated GPS] from Drop-down Menu • [Optional] Logged in User, Retrieve User/EV Preferences. Update. • [Option] Select destination location[Pre-populated GPS] from Drop-down Menu • Update Locations of (limited Number) EV Stations on a Map along Route
Alternative Flow2	• Enter Current Location, or Obtain Device GPS • Validate Address & Obtain GPS • [Optional] Logged in User, Retrieve User/EV Preferences. Update. • Update Locations of (limited Number) EV Stations on a Map
Alternative Flow3	• Enter Current Location, or Obtain Device GPS

	• [Option] Enter Destination Location • Validate Address & Obtain GPS • [Optional] Logged in User, Retrieve User/EV Preferences. Update. • Update Locations of (limited Number) EV Stations on a Map along Route

UC_2 EV Station Map with Navigation to EV Charge Point.

User Case	Use Case# & Name & : UC_2 EV Station Map with Navigation to EV Charge Point.
Primary Actor	EV Owners/Drivers.
Secondary Actor	Service Provider.
Description	EV Station Map with Navigation to EV Charge Point.
Basic Flow (Steps)	• Obtain Start location, Destination Location as Per UC_1 • [Optional] Logged in User, Retrieve User/EV Preferences. Update. • Present or obtain EV User Preference Data (e.g operator, amenities) relevant to Journey Planning for selection and filtering. • Present or obtain Electric Vehicle Data (e.g Model, Year, etc) relevant to Journey Planning for selection and filtering • Present or obtain Electric Vehicle Charging Data (e.g Starting %, safety Margin, etc) relevant to Vehicle Station Charging for selection and filtering • Find filtering List of Suitable EV Stations on the planned journey Route. • Select Optimal Stations to complete journey based on previous selections. • Calculate, Distance, Travel and Charging Times. • Display Journey Route on Map, with Charging station stops and Total Distance/Journey time(including charging)

UC_3 Broadcast Compatibility info & Update Vacancy/Capacity EV ChargePoint's Data in Real-time.

User Case	Use Case# & Name & : UC_3 Broadcast Compatibility info & Update Vacancy/Capacity EV Chargepoints Data in Real-time.
Primary Actor	Service Provider
Secondary Actor	EV Owners/Drivers.

Description	Broadcast Compatibility info & Update Vacancy & capacity EV Chargepoints Data in Real-time.
Basic Flow (Steps)	Sign up as EV Service Provider Add Current EV Charge Point Locations, Add & Connect Each individual EV ChargePoint to the Booking & Queue Management System. Broadcast EV Location & Compatibility Data in a Format for Display on a Map. Check for # Vacant EV ChargePoints with EV Capacity, If #Vacant EV Chargepoint > 0 , then Broadcast & Update any Vacancy & capacity EV Chargepoints Data in Real-time in a format for displaying on a map.
Alternative Flow	If #vacant EV ChargePoint =0 within EV ChargePoint Capacity, Broadcast & Update EV Chargepoints estimated wait times.

UC_4 Broadcast & Update EV Chargepoints estimated wait times.

User Case	**Use Case# & Name & : UC_4 Broadcast & Update EV Chargepoints estimated wait times.**
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Broadcast & Update EV Chargepoints estimated wait times.
Basic Flow (Steps)	Check for # Vacant EV ChargePoints with EV Capacity, If #vacant EV ChargePoint =0 within EV ChargePoint Capacity, Collect, Forecast & Update each EV Chargepoints estimated wait times. Calculate the minimum charge point waiting time. Broadcast & Update Vacancy & capacity EV Chargepoints Data in Real-time in a format for displaying on a map.
Alternative Flow	If #Vacant EV Chargepoint > 0 , then Broadcast & Update any Vacancy & capacity EV Chargepoints Data in Real-time in a format for displaying on a map.

UC_5 User Sign Up or Login In or Vehicle registration or Updates.

User Case	**Use Case# & Name & : UC_5 User Sign Up or Login In or Vehicle registration or Updates**
Primary Actor	EV Owners/Drivers.
Secondary Actor	Service Provider.
Description	User Sign Up or Login
Basic Flow (Steps)	Collect User details for user sign up including email, mobile phone number, DoB, Address, Collect Vehicle registration details. Allow users to add multiple vehicles to account.

Alternative Flow	Previously registered User signs in. Allow signed in users to select vehicle for booking or journey. Allow users to add multiple vehicles to account.

UC_6 Order & Scheduling Updates

User Case	**Use Case# & Name & : UC_6 Order & Scheduling Updates**
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Allow EV Owners or Driver update EV ChargePoint order & scheduling details
Basic Flow (Steps)	Users sign in. Current booking details can be amended or updated. Updated Booking details are stored. Updated booking details are communicated to the user. Ordering & Scheduling system is updated to reflect changes.
Alternative Flow	

UC_7 EV ChargePoint booking & Secured with Pre-payment

User Case	**Use Case# & Name & : UC_7 EV ChargePoint booking & Secured with Pre-payment**
Primary Actor	EV Owners/Drivers.
Secondary Actor	Service Provider.
Description	EV ChargePoint booking & Secured with Pre-payment
Basic Flow (Steps)	Allow user to select preferred EV ChargePoint on a Map. Allow the user to check and select from current and future available TimeSlot/Space from EV Chargepoint Capacity, Capture Vehicle Model Data from user to confirm Service Provider Compatibility & Service Offerings. Allow the user to select the appropriate service offering. Capture EV registration for Vechicle Model and Compatibility information with EV Charge Point. Capture EV registration for Vehicle Model Authentication at EV Charge Point. Capture User Data require for payment and Authentication at EV ChargePoint Calculate Reserve pre-Payment Total Based on Selected Service Offering user wants to secure. Collect Payment for Reserve and Booking EV ChargePoint and process transaction.
Alternative Flow	Allow user to select preferred EV ChargePoint on a Map. Allow the user to check and select from current and future available Timeslot/Space from EV ChargePoint Capacity,

	For a Signed-in User display and of the following available details: Vehicle Model, Vehicle registration, User Details, etc Allow the user to Change Vehicle details. Allow the user to add an additional Vehicle. Allow a user to manually enter vehicle range. Calculate Reserve pre-Payment Total Based on Selected Service Offering user wants to secure. Collect Payment for Reserve and Booking EV Chargepoint and process transaction.

UC_8 Secure Payment Transaction/Process.

User Case	Use Case# & Name & : UC_8 Secure Payment Transaction/Process.
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Secure Payment Transaction/Process.
Basic Flow (Steps)	Allow the EV Service Provider to display a pop-up to securely collect necessary logged in user payment details in a form as required for a payment processing services provider. Payment processing services provider processes payment. EV Service Provider receives confirmation of payment from the payment processing services provider. EV Service Provider Notifies User Payment has been process and confirms booking. EV Service Provider sends SMS Alerts/Notification of booking details and payment amounts. EV Service Provider also sends SMS Alerts/Notification Service Delivery Protocols at the booked specific location.
Alternative Flow	

UC_9 Seamless Service Delivery / Vehicle Charging.

User Case	Use Case# & Name & : UC_9 Seamless Service Delivery / Vehicle Charging.
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Seamless Service Delivery / Vehicle Charging
Basic Flow (Steps)	Automatic Vehicle Authentication upon arrival using vehicle registration. Add vehicle to automatic queue system. Alert via SMS & Guide the use to a vacant EV Charge point. Perform safety checks when vehicle has moved to the required EV ChargePoint.

	Perform User Authentication using 2 factor SMS identification to initiate recharging. Alert User 5 mins before full charging is achieved. Display Full Charging payment details. Process Payment for Service Delivery. Finalise Payment Transactions Details and send notification to User. Confirm Use has moved vehicle and EV Charge Point has become vacant. Update automatic queue system.
Alternative Flow	

UC_10 Demand Forecasting

User Case	Use Case# & Name & : UC_10 Demand Forecasting
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Demand Forecasting
Basic Flow (Steps)	Log Search History Data Relevant to Demand forecasting for both registered and non-registered users. Record Historical Demand Data from Transactions. Predict a 4 week future demand windows based on recent Log Search history trends and Historical Data trends.
Alternative Flow	

UC_11 Supply Procurement

User Case	Use Case# & Name & : UC_11 Supply Procurement
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Supply Procurement
Basic Flow (Steps)	Review Demand Forecast, Calculate Supply required to meet demand. Calculate Energy Storage Capacity. Procure Energy Supply at off-peak periods.
Alternative Flow	

UC_12 Specific EV Chargepoint Value Add-Services & Amenities.

User Case	Use Case# & Name & : UC_12 Specific EV Chargepoint Value Add-Services & Amenities.
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Specific EV Chargepoint Value Add-Services & Amenities.
Basic Flow (Steps)	Publish Service Provider USP/Features/Advantages.

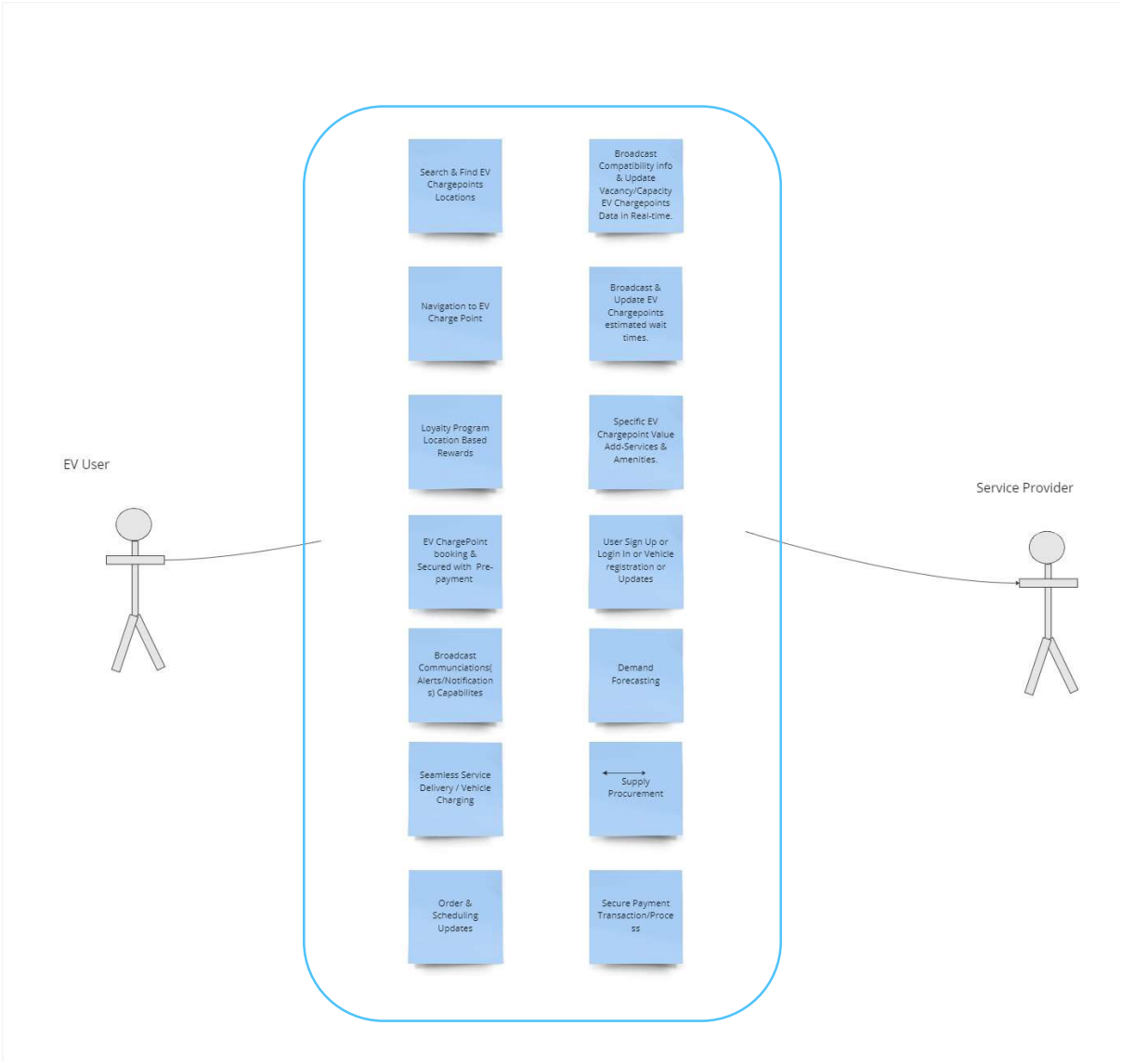
	Publish value-add services from service provider. Publish value-add services from local partners. Publish adult and child amenities at EV location.
Alternative Flow	

UC_13 Loyalty Program Location Based Rewards

User Case	**Use Case# & Name & : UC_13 Loyalty Program Location Based Rewards**
Primary Actor	Service Provider.
Secondary Actor	EV Owners/Drivers.
Description	Loyalty Program
Basic Flow (Steps)	Automatically add signed up/registered users to the Loyalty Program. Store rewards in registered users accounts. Increase rewards as transaction amount increases. Publish rewards programs service provider and partner offers and discounts.
Alternative Flow	

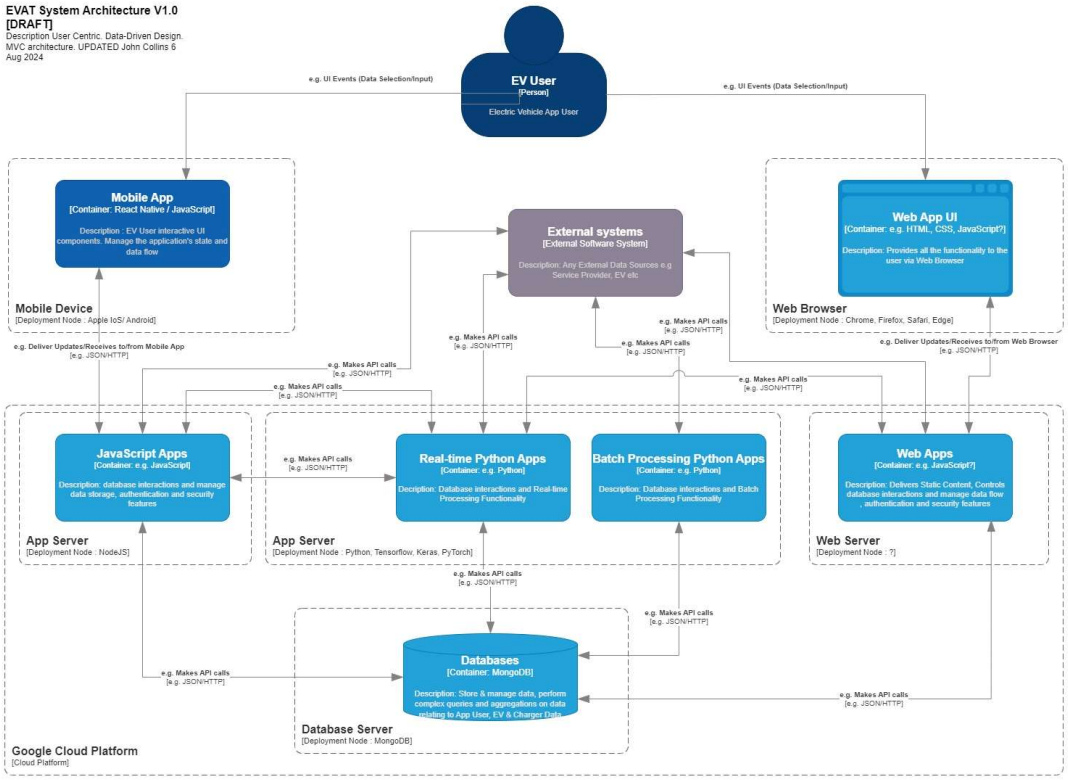
Use Case Model

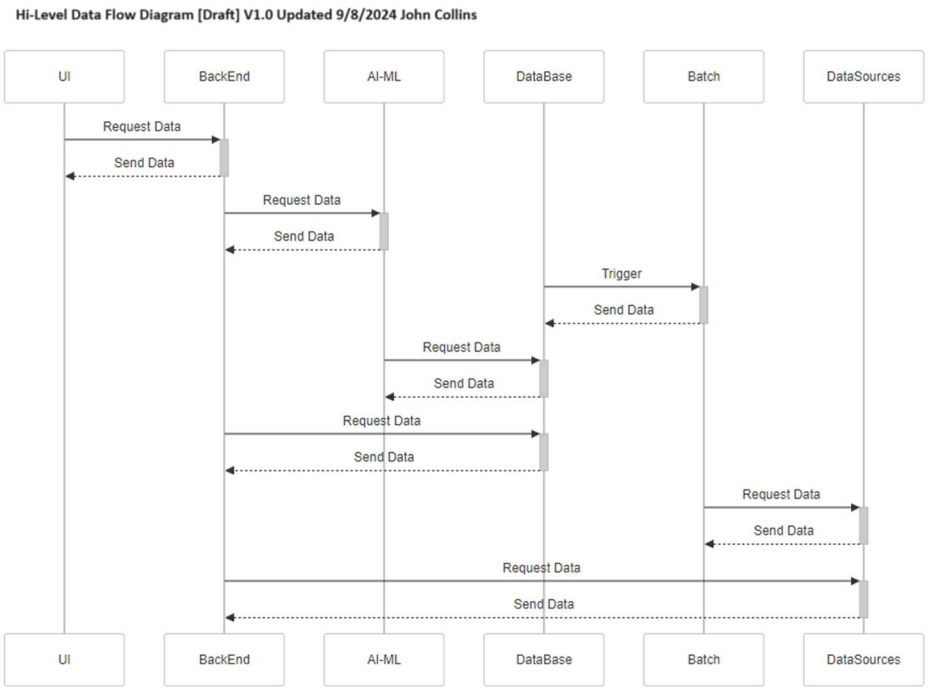
The use case model helps the developers developing the system, in identifying what the user wants from the overall system and how the system captures the user stories. The use case model contains all the system use cases.



Proposed System Architecture & Data Flow

A high-level overview of a System architecture with a user interfaces (UI), servers, and databases is as follows:

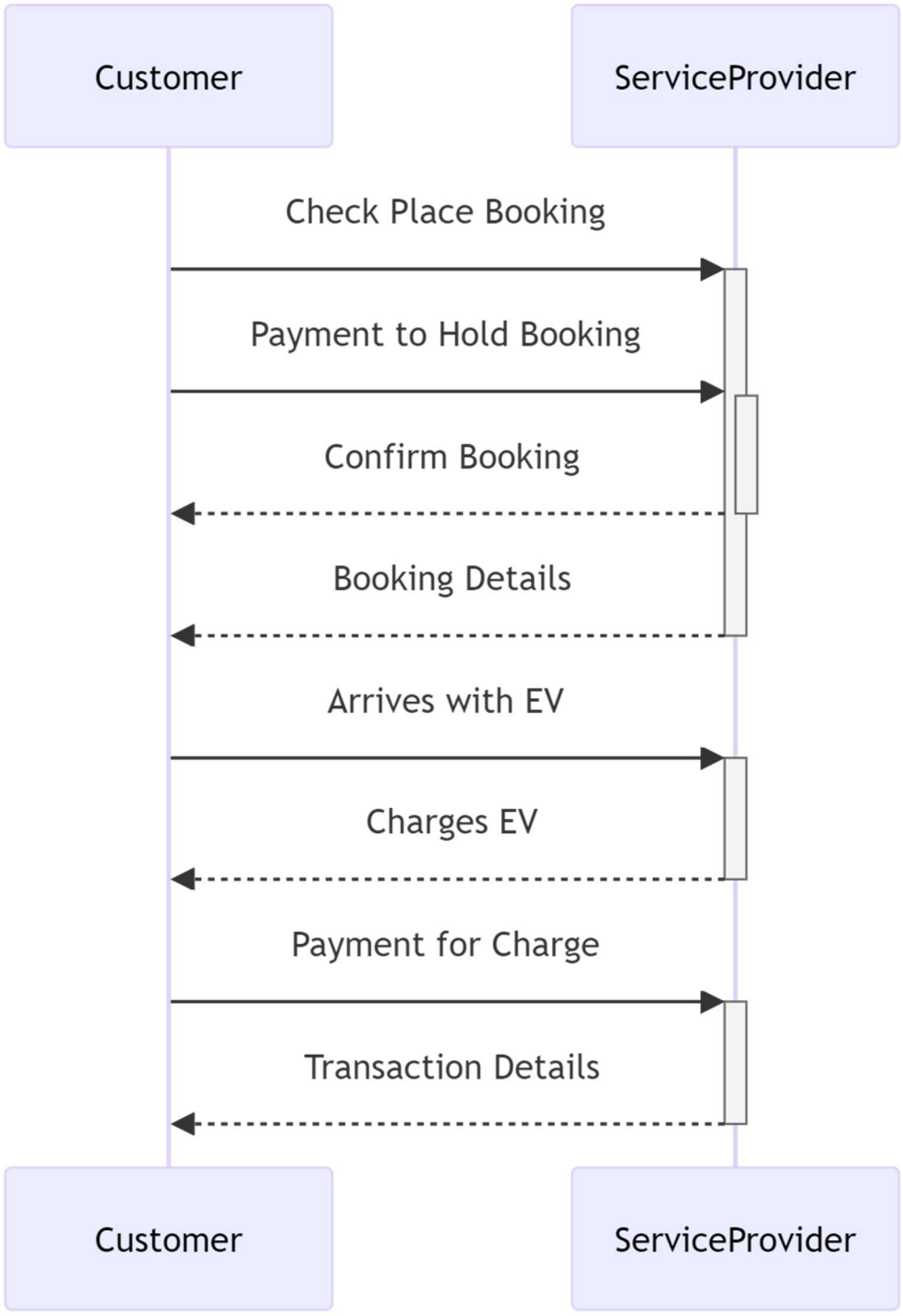




Information Architecture

Use Case Model Hi-Level Data Flow Diagram

A data flow diagram (DFD) is a visual representation of the flow of information through a system or process. It's a fundamental tool in system analysis and design, used to map out how data enters, transforms, and exits a system. Here's a breakdown of interaction between the different system components:



Data Flow Diagram Components:

The simple DataFlow Diagram can be expanded to deeper levels and informed by the system architecture to include:

- *External Entities*: Represent systems or entities outside the system of interest, which send or receive data (e.g., customers, databases, other applications).
- *Processes*: Represent steps or activities within the system that transform data (e.g., calculations, data validation, data manipulation).
- *Data Stores*: Represent repositories where data is stored (e.g., databases, files, temporary memory).
- *Data Flows*: Represent the movement of data between components, shown as arrows with labels indicating the nature of the data.

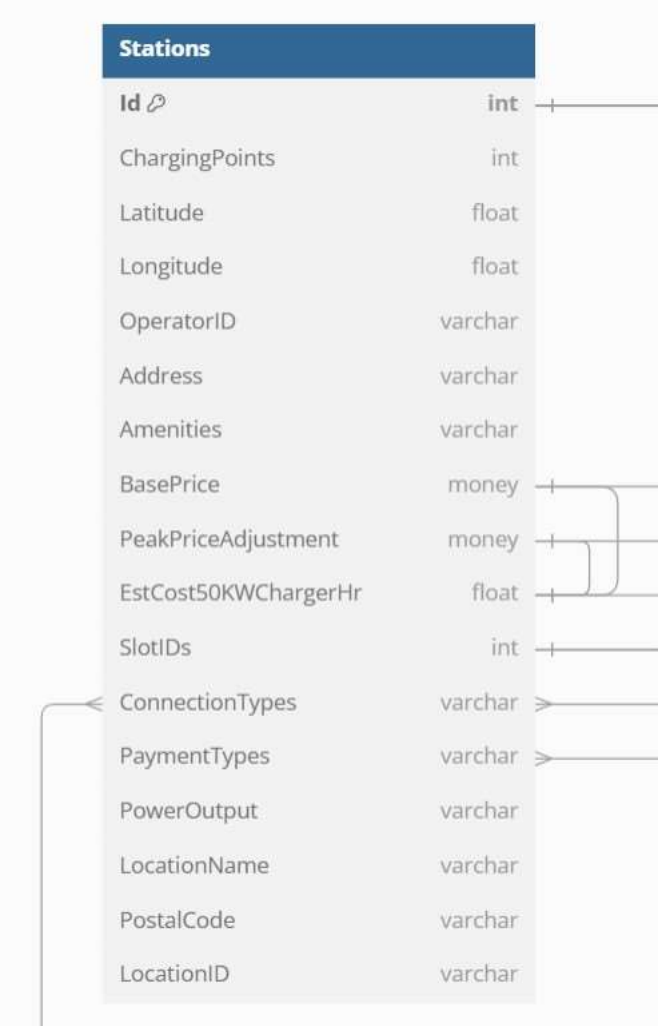
Domain Class Models (Data Entities)

The Doman Class Models are the basic foundational Building Blocks for the Data Base Implementation:

ev: Contains information about electric vehicles, including manufacturer, model, vehicle year, and battery capacity.
Users: Includes user details such as first name, surname, email, and role.
Stations: Details about charging stations, including location, operator, and amenities.
OrderScheduling: Information on order scheduling, including booking dates and slot times.
ChargingSession: Data on charging sessions, including start and end times, and total kWh charged.
UserPayment: Payment details related to user transactions.
PurchaseWholesaleElec: Information on wholesale electricity purchases.

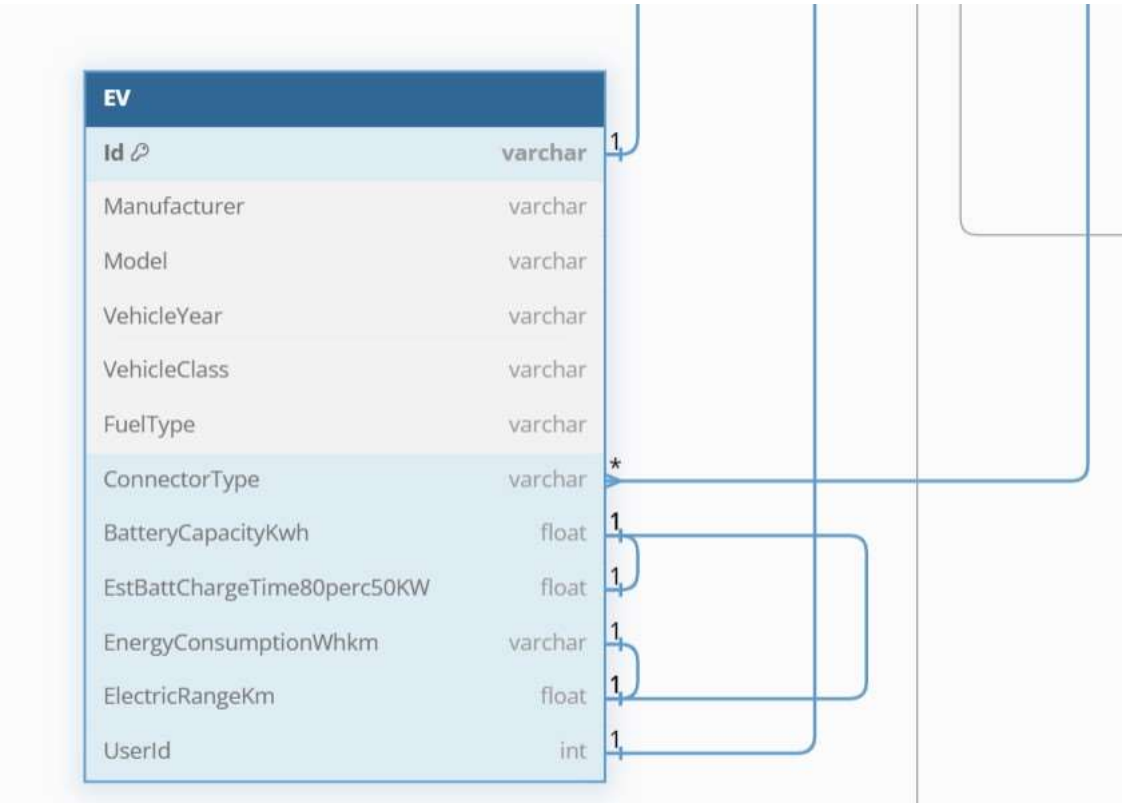
Detailed Class Models for these tables are given below

Class Model EV Station Data



Class Model Electric Vehicle Data

The Domain Class Model for the Electric Vehicle is as follows:

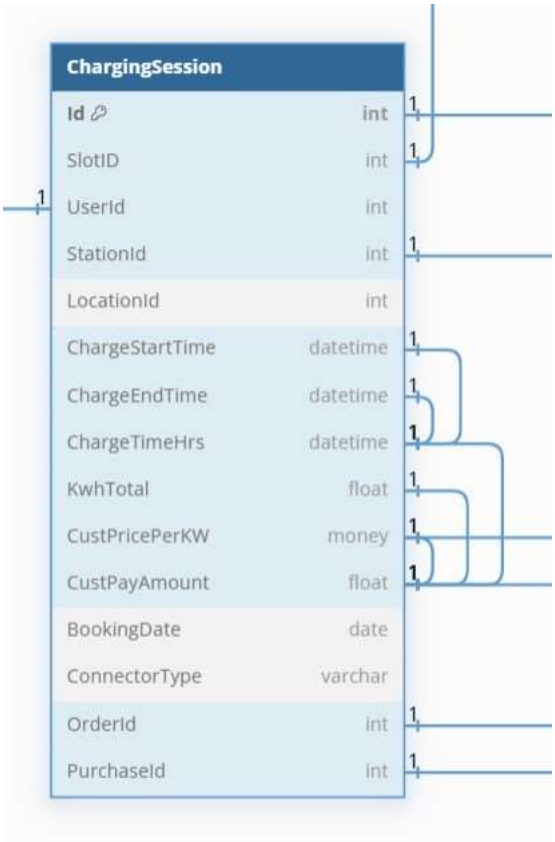


Class Model EV User Data

The Domain Class Model for the user is as follows:

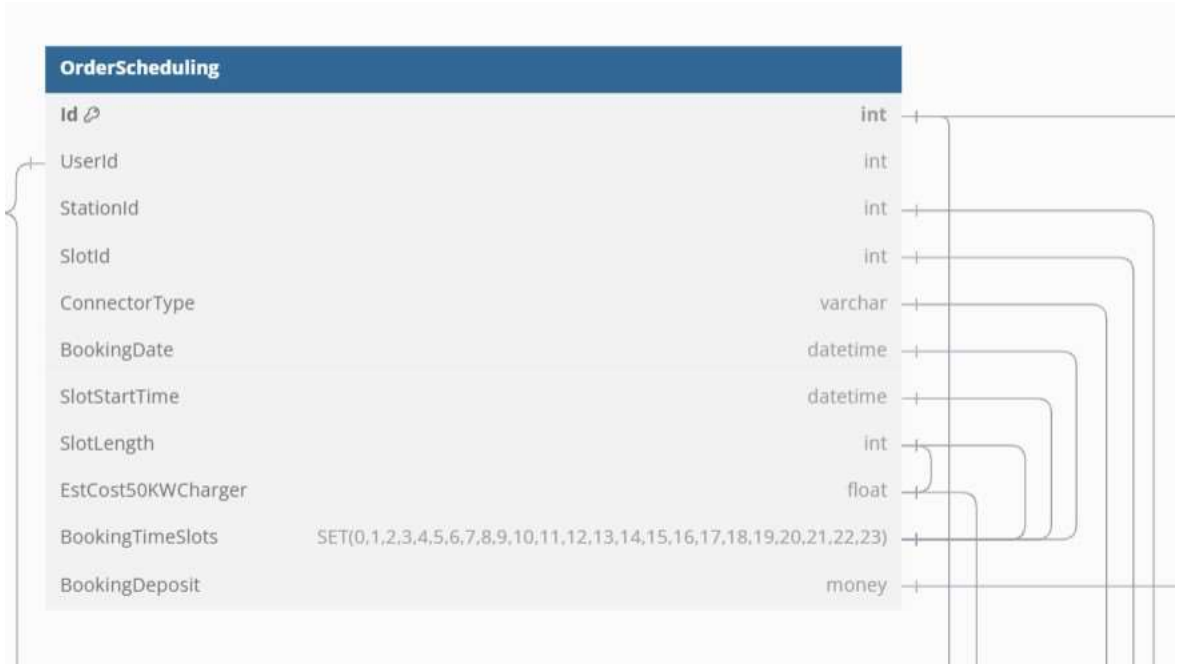
Class Model Charging Session Data

The Domain Class Model for the Charging Session is as follows:



Class Model Order Scheduling (Booking) Data

The Domain Class Model for the Order Scheduling (Booking) is as follows:

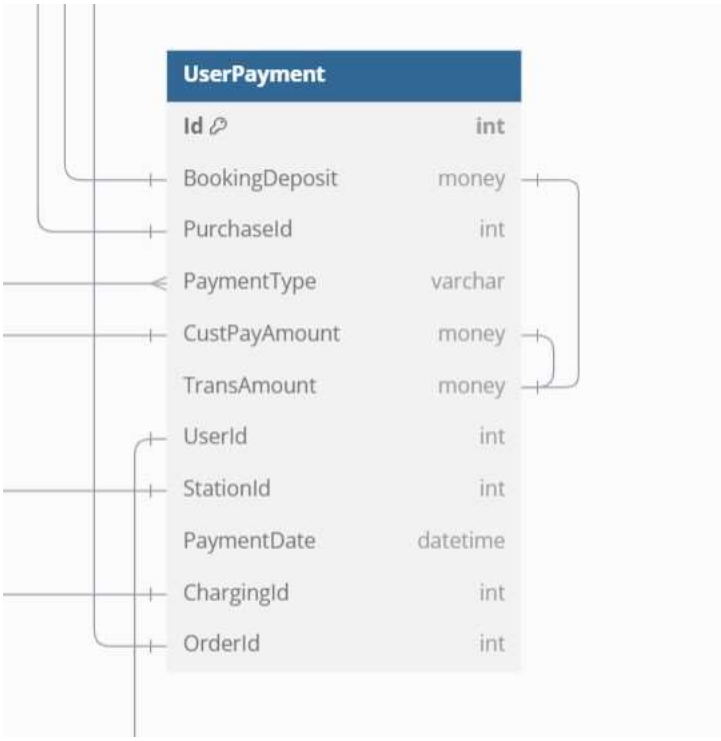


Class Model Purchase Wholesale Electricity Data

The Domain Class Model for the Purchase Wholesale Electricity is as follows:

Class Model User Payment Data

The Domain Class Model for the User Payment is as follows:



Data Model

The domain class model has been previously described. The data model focuses on the physical representation of data within the chosen storage system (e.g., relational database, NoSQL database).

- Defines the structure of data, including tables, columns, data types, constraints, and relationships between tables. This configuration includes:
  - Table names and their primary keys.
  - Columns with their data types.
  - Foreign keys with context specified where applicable.

- The relationships between the tables are defined using foreign keys, which connect columns from one table to another. Here is the structure of these relationships:
  - **Users** table has a foreign key VehicleID that references the Id column in the ev table.
  - **OrderScheduling** table has foreign keys UserId referencing Id in Users and StationId referencing Id in Stations.
  - **ChargingSession** table has foreign keys OrderId referencing Id in OrderScheduling, UserId referencing Id in Users, StationId referencing Id in Stations, and PurchaseId referencing Id in PurchaseWholesaleElec.
  - **UserPayment** table has foreign keys PurchaseId referencing Id in PurchaseWholesaleElec, StationId referencing Id in Stations, UserId

referencing Id in Users, OrderId referencing Id in OrderScheduling, and ChargingId referencing Id in ChargingSession.

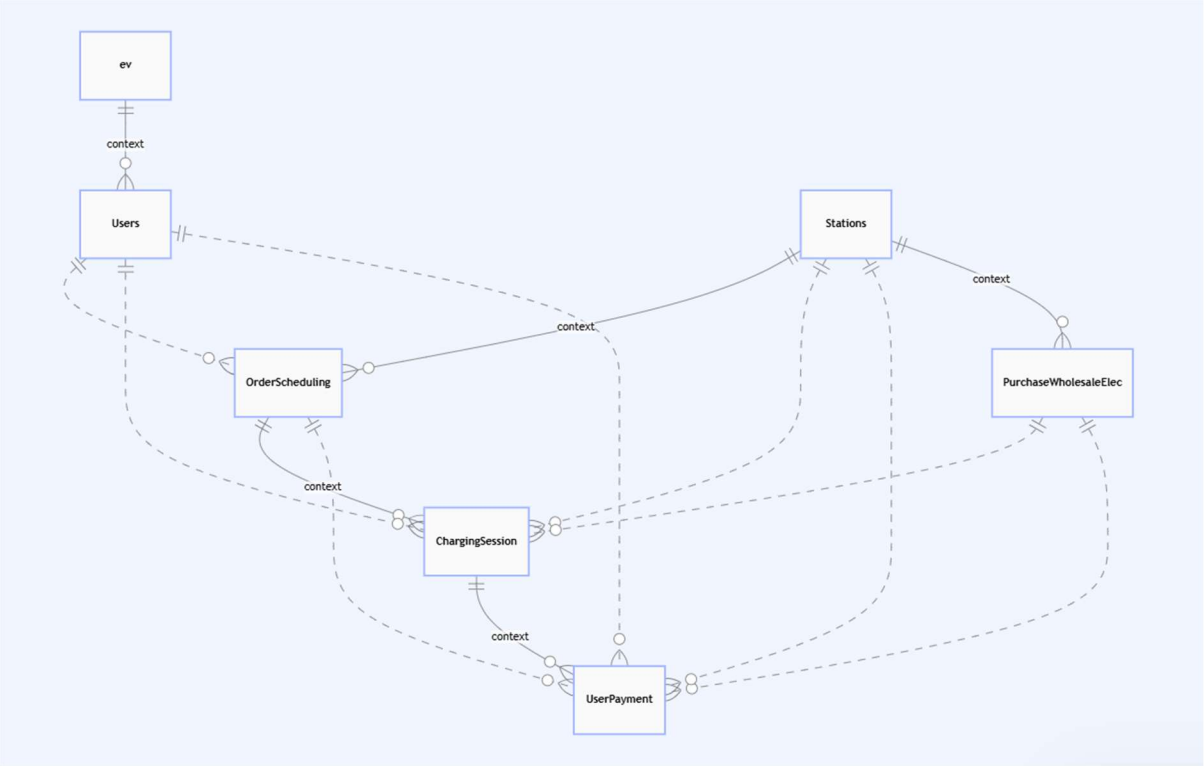
- **PurchaseWholesaleElec** table has a foreign key StationId referencing Id in Stations.

These relationships help maintain data integrity and allow for complex queries across multiple tables.

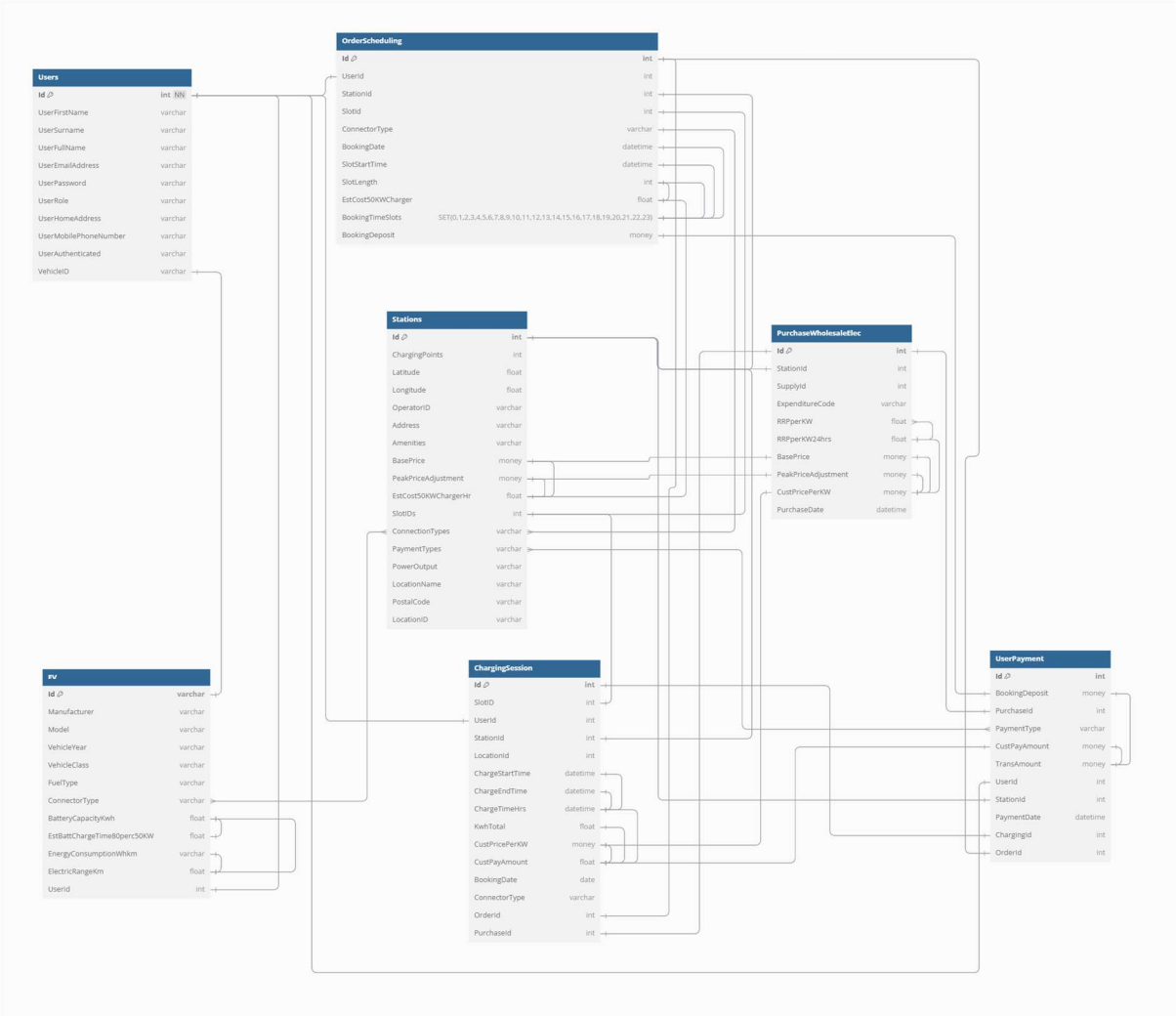
Conceptual Domain Class Model Diagram

A Domain Class Model Diagram (DCM) is a visual representation of the core concepts and their relationships within a specific problem/solution domain. It's used in software development to understand and communicate the structure of the problem domain before diving into technical implementations such as:

- Classes: Represent real-world entities or concepts relevant to the domain (e.g., Customer, Product, Order).
- Attributes: Describe the properties of each class (e.g., customer name, product price, order date).
- Relationships: Show how classes are connected (e.g., a customer can place many orders, a product can belong to a category).



Data Model Detailed



Data Model Tools & Links

Database definition

Use DBML to define your database structure using a free tool dbdiagram.io

- **Github Link** **EVAT-Data-Science/personal-work/john-collins/Testing-Data-Model-Development/dbdiagram.io Database Design at john-collins-documentation · Chameleon-company/EVAT-Data-Science**
- **Database Documentation Link**: https://dbdocs.io/s223617689/Chameleon_EVAT?schema=public&view=relationships&table=Users
- **Database Link** https://dbdiagram.io/d/EVAT1-675f6402e763df1f00025c09

Data Model CSV Output Files

These are the foundational database files

EVAT-Data-Science/personal-work/john-collins/Testing-Data-Model-Development/Data Model CSV Output Files at john-collins-documentation · Chameleon-company/EVAT-Data-Science

Data Model Seed Input Files

These are the seed csv files required to generate the Data Model using a python script

EVAT-Data-Science/personal-work/john-collins/Testing-Data-Model-Development/Data Model Seed Input Files at john-collins-documentation · Chameleon-company/EVAT-Data-Science

Generative AI Dataset Expansion

This work attempts to expand the Foundational Database entries using generative AI

EVAT-Data-Science/personal-work/john-collins/Testing-Data-Model-Development/Generative AI DataSet Expansion at john-collins-documentation · Chameleon-company/EVAT-Data-Science

This work was completed using mostyAI [13]

Database Implementation & Restoration of Data Model

The database was implemented in PostgreSQL.

PostgreSQL Database

Database: EVAT_TEST1
Owner: postgres
Password: EVAT_ADMIN

PG Restore

The database can be full restored from the following github:
EVAT-Data-Science/personal-work/john-collins/Testing-Data-Model-Development/PostgreSQL_Database at john-collins-documentation · Chameleon-company/EVAT-Data-Science

Dockerisation

The PostgreSQL database can be dockerised.

Additional : User Location & Routing Data Use cases (Location/Navigation Data/Journey)

Class Model User Location& Routing Data (Location/Navigation Data/Journey)

Class Model	Class Model Name: User Location & Routing Data

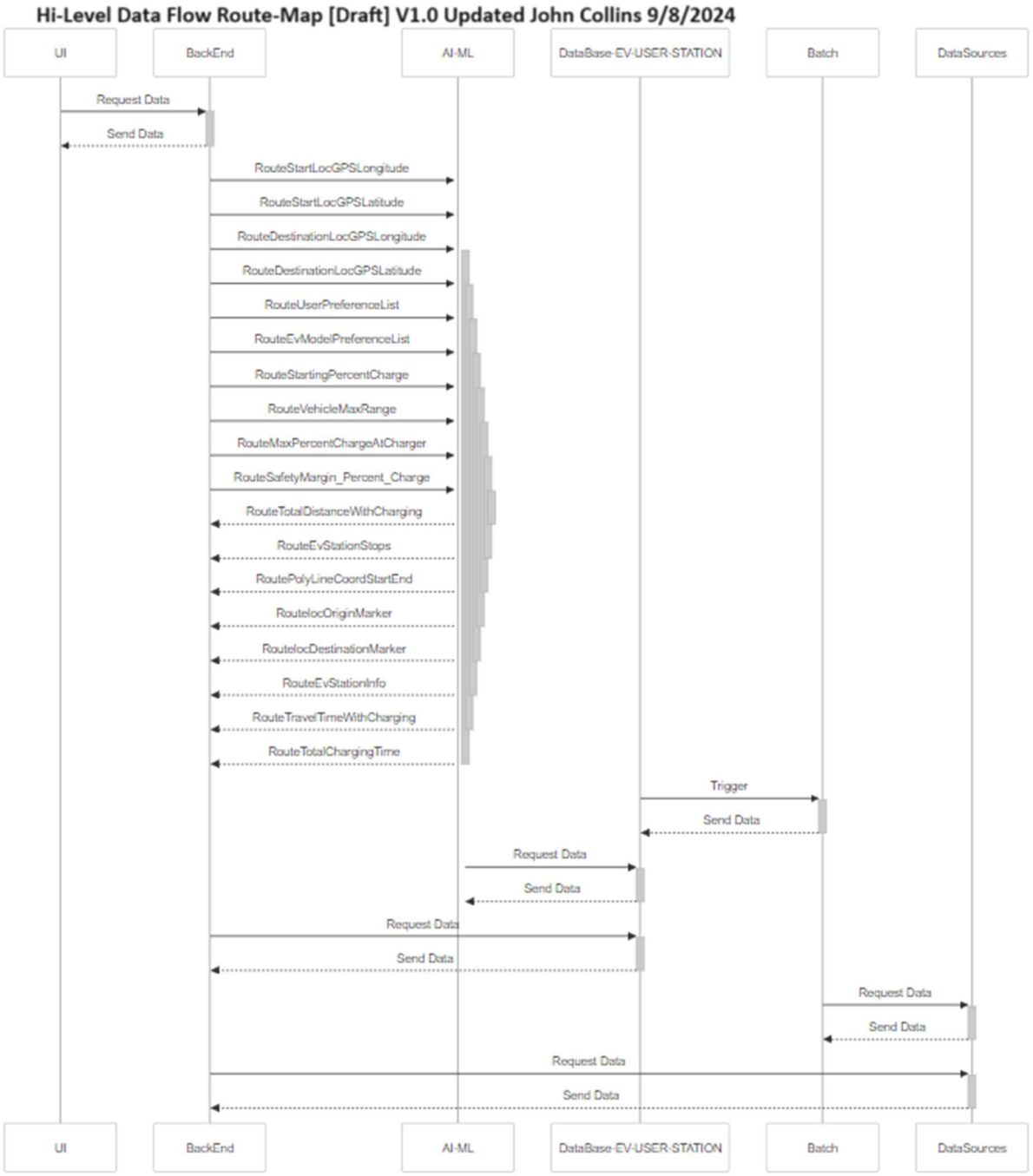
RouteStartLocMenuList	• Static List Top50 most populated Cities
	• [Optional: Dynamic User Specific List]
	
	`australian_cities_location = {`
	`"Sydney": [151.2093, -33.8688],`
	`"Melbourne": [144.9631, -37.8136],`
	`"Brisbane": [153.0251, -27.4698],`
	`"Perth": [115.8605, -31.9505],`
	`"Adelaide": [138.6007, -34.9285],`
	`"Gold Coast": [153.4000, -28.0167],`
	`"Canberra": [149.1300, -35.2809],`
	`"Newcastle": [151.7789, -32.9267],`
	`"Central Coast": [151.2333, -33.2833],`

	"Sunshine Coast": [153.0667, -26.6500], "Wollongong": [150.8931, -34.4278], "Hobart": [147.3250, -42.8821], "Geelong": [144.3500, -38.1500], "Townsville": [146.8139, -19.2580], "Cairns": [145.7700, -16.9186], "Darwin": [130.8456, -12.4634], "Toowoomba": [151.9555, -27.5614], "Ballarat": [143.8503, -37.5622], "Bendigo": [144.2811, -36.7570], "Albury-Wodonga": [146.9278, -36.0737], "Mackay": [149.1860, -21.1412], "Rockhampton": [150.5044, -23.3774], "Launceston": [147.1543, -41.4381], "Bunbury": [115.6383, -33.3256], "Hervey Bay": [152.8400, -25.2888], "Maitland": [151.5500, -32.7333], "Wagga Wagga": [147.3636, -35.1150], "Coffs Harbour": [153.1250, -30.2963], "Mildura": [142.1625, -34.2083], "Shepparton": [145.3889, -36.3833], "Gladstone": [151.2583, -23.8478], "Tamworth": [150.9167, -31.0833], "Port Macquarie": [152.9185, -31.4333], "Orange": [149.1000, -33.2833], "Dubbo": [148.6167, -32.2500], "Geraldton": [114.6000, -28.7667], "Nowra": [150.6000, -34.8833], "Bathurst": [149.5765, -33.4193], "Warrnambool": [142.4794, -38.3817], "Lismore": [153.2744, -28.8135], "Albany": [117.8814, -35.0231], "Kalgoorlie-Boulder": [121.4667, -30.7500], "Devonport": [146.3419, -41.1770], "Mount Gambier": [140.7800, -37.8284], "Burnie": [145.9167, -41.0500], "Whyalla": [137.5833, -33.0333] }
RouteDestinationLocMenuList	As per EvUserCurrentLocMenuList above (Minus Start Location)
RouteStartLocAddress	String e.g 100 George Street, Sydney, NSW.
RouteDestinationLocAddress	String e.g 100 Collins Street, Melbourne, VIC
RouteStartLocGPSLongitude	Float e.g 151.2093
RouteStartLocGPSLatitude	Float e.g -33.8688
RouteDestinationLocGPSLongitude	Float e.g 144.9631

RouteDestinationLocGPSLatitude	Float e.g -37.8136
RouteUserPreferenceList	Selectable From: • EvStationAmenities • EvStationOperator
RouteEvModelPreferenceList	Selectable/Prepopulate : Class Model EV User Data • EvMake • EvModel • EvYear • EvMaxRange • EvSocketCompatibility • EvChargePowerOutputs • EvChargeServiceTimes
RouteStartingPercentCharge	Integer e.g
RouteVehicleMaxRange	Integer e.g Range[1 to 400]
RouteMaxPercentChargeAtCharger	Integer e.g Range [1 to 100] (converted to a percentage subsequenctly)
RouteSafetyMargin_Percent_Charge	Integer e.g Range [1 to 10] (converted to a percentage subsequenctly)
RouteTotalDistanceWithCharging	Float (returned Calculation) e.g 659.68
RouteEvStationStops	Integer (returned Calculation) e.g 2
RoutePolyLineCoordStartEnd	Float list e.g PolyLine [(-35.28075, 149.12981), (-35.2808, 149.12975), (-35.28087, 149.1297), (-35.28098, 149.12972), (-35.28216, 149.1304) ……. (-34.81646, 148.44058), (-34.81659, 148.43911), (-34.81659, 148.43876)]
RoutelocOriginMarker	Float List e.g [-35.2809, 149.13] GPS
RoutelocDestinationMarker	Float List e.g [-37.8136, 144.9631] GPS
RouteEvStationInfo	String List e.g StationI etc [{'ID': 296044, 'Distance_LastLeg': 282.74, 'Distance_Remaining': 376.85, 'Coordinates': [147.3171930996939, -35.7229067434558], 'Coordinates reversed': [-35.7229067434558, 147.3171930996939]},

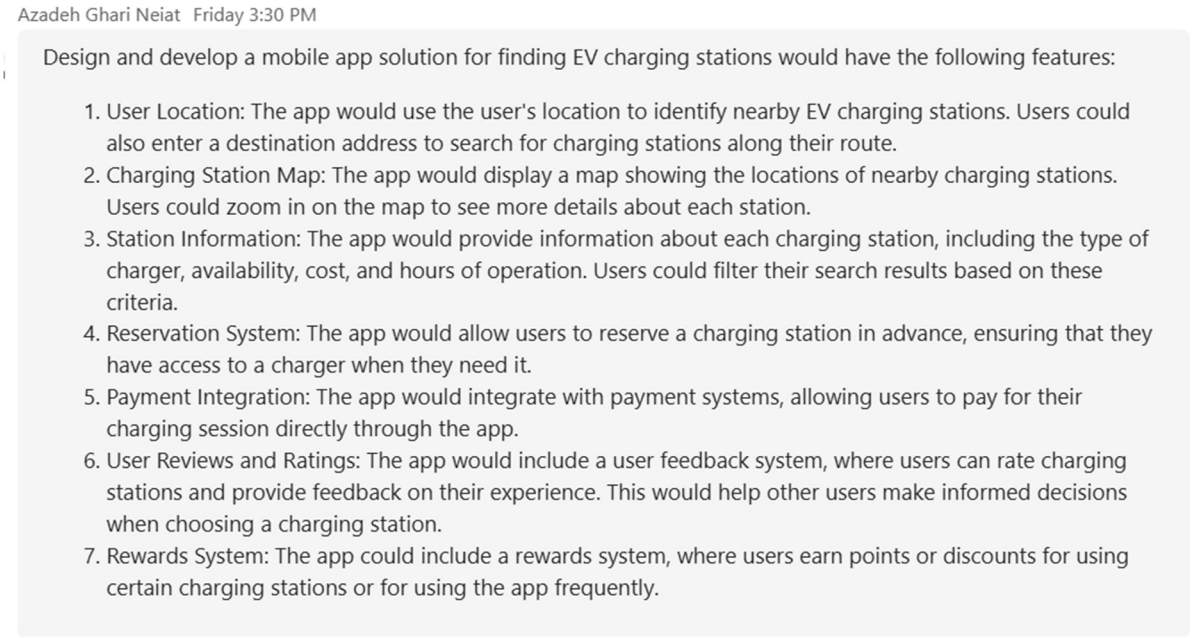
	{'ID': 210929, 'Distance_LastLeg': 314.57, 'Distance_Remaining': 70.63, 'Coordinates': [144.952084, -37.294362], 'Coordinates reversed': [-37.294362, 144.952084]}])
RouteTravelTimeWithCharging	TBC - estimated
RouteTotalChargingTime	TBC - dervived
Time_stamp	DateTime

DataFlow User Location& Routing Data (Location/Navigation Data/Journey)


Hi-Level Data Flow Route-Map [Draft] V1.0 Updated John Collins 9/8/2024
UI
BackEnd
AI-ML
DataBase-EV-USER-STATION
Batch
DataSources
Request Data
Send Data
RouteStartLocGPSLongitude
RouteStartLocGPSLatitude
RouteDestinationLocGPSLongitude
RouteDestinationLocGPSLatitude
RouteUserPreferenceList
RouteEvModelPreferenceList
RouteStartingPercentCharge
RouteVehicleMaxRange
RouteMaxPercentChargeAtCharger
RouteSafetyMargin_Percent_Charge
RouteTotalDistanceWithCharging
RouteEvStationStops
RoutePolyLineCoordStartEnd
RoutelocOriginMarker
RoutelocDestinationMarker
RouteEvStationInfo
RouteTravelTimeWithCharging
RouteTotalChargingTime
Trigger
Send Data
Request Data
Send Data
Request Data
Send Data
Request Data
Send Data
Request Data
Send Data
UI
BackEnd
AI-ML
DataBase-EV-USER-STATION
Batch
DataSources

Appendix – Record Decisions/Meeting Minutes

[A] Company Directors meeting 26/7/2024



Azadeh Ghari Neiat Friday 3:30 PM

Design and develop a mobile app solution for finding EV charging stations would have the following features:

1. User Location: The app would use the user's location to identify nearby EV charging stations. Users could also enter a destination address to search for charging stations along their route.
2. Charging Station Map: The app would display a map showing the locations of nearby charging stations. Users could zoom in on the map to see more details about each station.
3. Station Information: The app would provide information about each charging station, including the type of charger, availability, cost, and hours of operation. Users could filter their search results based on these criteria.
4. Reservation System: The app would allow users to reserve a charging station in advance, ensuring that they have access to a charger when they need it.
5. Payment Integration: The app would integrate with payment systems, allowing users to pay for their charging session directly through the app.
6. User Reviews and Ratings: The app would include a user feedback system, where users can rate charging stations and provide feedback on their experience. This would help other users make informed decisions when choosing a charging station.
7. Rewards System: The app could include a rewards system, where users earn points or discounts for using certain charging stations or for using the app frequently.

Background Information : Data Science Jupyter Notebooks Variables & Github links

EV_Route_Planning.ipynb

Jupyter Notebook Name	Type	Shape	Example Value	Desription
Starting_Percent_Charge	int		95	This is the current charge percent of the vehicle at the start of the journey.
Vehicle_Max_Range	int		400	This is the range of the vehicle when charged to 100%
Max_Percent_Charge_at_Charger	int		80	This is the maximum amount of charge that will be applied when stopping at an EV Charger. When stopping and charging at charging stations the rate of charge (speed) is dependent on the current charge amount. Charging vehicles from 80% to 100% is typically much slower than the rate of charge from 10% to 80%. Therefore when

				travelling it is unlikely you will charge to 100% unless stopped overnight.
Safety_Margin_Percent_Charge	int		10	This is the amount of charge the user would like remaining when they reach a charging station. Think of this like the petrol light. The algorithm will limit the driving distance such that the vehicle charge percent will not go below the safety margin
Location_Type_Selector	bool		TRUE	Location Type Selector. Yes = Select from City List. No = Select Long and Lat
Location_Start_City	str	8 chars	'Canberra'	Select your destination from the list of available cities/towns (top 50 by population)
Location_End_City	str	9 chars	'Melbourne'	Select your destination from the list of available cities/towns (top 50 by population)
Longtitude_Start	float		145.1149	Enter you origin (long/lat) and destination (long/lat).
Latitude_Start	float		-37.8475	Enter you origin (long/lat) and destination (long/lat).
Longtitude_End	float		141.4608	Enter you origin (long/lat) and destination (long/lat).
Latitude_End	float		-31.9596	Enter you origin (long/lat) and destination (long/lat).
user_startingpercent	float		0.95	= Starting_Percent_Charge / 100.0
user_safetymargin	float		0.1	= Safety_Margin_Percent_Charge / 100.0
user_maxchargepercent	float		0.8	= Max_Percent_Charge_at_Charger / 100.0
const_maxstops	int		20	The route planning algorithm can get lost in some scenarios. Therefore a limit of 20 stops has been implemented. Testing shows that for the default setup on the current EV charger network it takes 14 stops to navigate from Sydney to Perth. Therefore is the system reaches 20 stops it is assumed that the algorithm has failed to find a route and will exit the loop
op_startingrange				= (user_maxrange * user_startingpercent) - (user_maxrange * user_safetymargin)

op_normalrange				= user_maxrange * user_maxchargepercent
initial_distance_nochargers				RouteTotalDistanceWithCharging
i,				RouteEvStationStops
route_coordinates				RoutePolyLineCoordStartEnd
loc_origin_marker				RoutelocOriginMarker
loc_destination_marker				RoutelocDestinationMarker
df_routeinfo				RouteEvStationInfo
				RouteTravelTimeWithCharging
				RouteTotalChargingTime

References

[1] *Electric Vehicle Charging Shifts into High Gear*. (2022, July 20). Bain. https://www.bain.com/insights/electric-vehicle-charging-shifts-into-high-gear/

[2] *Winning the Battle in the EV Charging Ecosystem*. (2021, April 17). BCG Global. https://www.bcg.com/publications/2021/the-evolution-of-charging-infrastructures-for-electric-vehicles

[3] e-motec. (2020, November 19). *Bringing India's first public electric vehicle charging network online with TCS ChargeCore on HOBS™*. E-Motec. https://www.e-motec.net/evs-charging-infrastructure-tcs-chargecore-on-hobs

[4] *The Ultimate Guide To Electric Vehicles & Electric Vehicle Charging - Zenergi*. (2021, May 28). Zenergi.co.uk. https://zenergi.co.uk/latest/the-ultimate-guide-to-electric-vehicles-electric-vehicle-charging-2021/

[5] *Electric Trucks – North American Council for Freight Efficiency*. (n.d.). Retrieved February 10, 2024, from https://nacfe.org/research/electric-trucks/#amping-up-charging-infrastructure-for-electric-trucks

[6] *The Future of Electric Vehicles: Mobile Energy Storage Devices | EVAdoption*. (2018, February 18). https://evadoption.com/the-future-of-electric-vehicles-mobile-energy-storage-devices/

[7] Singh, H., Pal, P. and Garg, P. (2021). *Sustainable Development Through Engineering Innovations*. Springer Nature. (p431 Sketching of EV Network: A Complete Roadmap)

[8] Chokkalingam, B., Padmanaban, S., Siano, P., Krishnamoorthy, R. and Selvaraj, R. (2017). Real-Time Forecasting of EV Charging Station Scheduling for Smart Energy Systems. *Energies*, 10(3), p.377. doi:https://doi.org/10.3390/en10030377.

[9] Sanguesa, J.A., Torres-Sanz, V., Garrido, P., Martinez, F.J. and Marquez-Barja, J.M. (2021). A Review on Electric Vehicles: Technologies and Challenges. *Smart Cities*, [online] 4(1), pp.372–404. doi:https://doi.org/10.3390/smartcities4010022.

[10] Sumedha Rajakaruna, Farhad Shahnia and Ghosh, A. (2014). *Plug In Electric Vehicles in Smart Grids*. Springer.

[11] Microsoft co-pilot

[12] Google geminin

[13] MOSTLY AI. (n.d.). *MOSTLY AI: The Synthetic Data Generator and Knowledge Hub*. [online] Available at: https://mostly.ai/.